CROP YIELD INCREASES REQUIRED TO JUSTIFY SUBSURFACE DRAINAGE INSTALLATION COSTS IN THE LOWER MISSISSIPPI VALLEY[1]

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ABSTRACT

Subsurface drainage field tests were conducted in Louisiana during 1974-1990 to determine if the value of the increase in crop yields attributed to subsurface drainage was sufficient to pay within 10 years the cost of installing the drains. Tests were conducted on Mhoon silty clay loam, Commerce silt loam, Jeanerette silty clay loam, Baldwin silty clay and Sharkey clay, all soil types common in the lower Mississippi Valley. The fifteen drain spacings tested varied from 5.5m(18ft) on clay soil to 48.8m(160ft) on silt loam. Crop yield responses were measured for sugarcane, wheat, soybeans, and corn silage. The cost of installing subsurface drainage, including 10 percent interest, was justified for Commerce silt loam with 24.4m(80ft) drain spacing for sugarcane, Jeanerette silty clay loam with 27.4m(90ft) and 41.1m(135ft) drain spacing for sugarcane, and Commerce silt loam with 20m(66ft) and 30.5m(100ft) drain spacing for corn silage. The cost of installing subsurface drainage on Baldwin silty clay for sugarcane and Sharkey clay soil for sugarcane, wheat, and soybeans was not justified using the guidelines selected for this study.

Key words: Subsurface-drainage economics sugarcane wheat soybeans corn-silage

INTRODUCTION

Fertile alluvial soil, nearly flat topography, relatively long frost-free growing seasons, and an abundance of water are natural resources available to farmers in the lower Mississippi Valley of the United States. A common problem in the valley, however, is excess rainfall and the resulting high water tables which inhibit crop growth, reduce yield, and interfere with timely field operations. Average annual rainfall in Baton Rouge, Louisiana is 1417mm(55.8in) but varies from 1061mm(41.8in) to 2243mm(88.3in).

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For many years, farmers tolerated excess water without considering ways to alleviate it. The perception was that the alluvial soils in the lower Mississippi Valley were too fine textured to respond to subsurface drainage. This perception was reinforced by Lund and Loftin (1960) and by Lund et al. (1961) which indicated that the saturated hydraulic conductivity of many soils was very low. Research by Carter et al. (1970), Carter and Floyd (1971) and Camp and Carter (1977), proved this perception false. Carter and Floyd (1973) used concrete bordered plots, 40 m^2($436ft^2$) in size, to determine that subsurface drainage could adequately control water tables in the fine textured soils in the lower Mississippi Valley. Subsurface drainage research was expanded to field-size areas by Camp and Carter (1983) and by Bengtson, et al., (1982). Additionally, a large sugarcane field had subsurface drains installed where subsurface drainage flow could be controlled, and subirrigation water was provided for automated water table depth control (Carter et al., 1988).

That soils in the lower Mississippi Valley respond favorably to subsurface drainage has been generally known for more than 10 years; however, subsurface drainage is not yet commonly installed by farmers in the valley. The primary reasons that farmers have delayed installing subsurface drainage are the costs of installation and the uncertainty of future prices of farm products. Actual drain installation costs are difficult to determine because there are no drainage contractor businesses located in the valley to provide this information. Furthermore, many drainage system designs would require sumps and pumps as drainage outlets because field ditches are either too shallow to serve as outlets or because they fill quickly with water during rainstorms, making them ineffective.

The texture of the soils in the lower Mississippi Valley vary from clay to silt loam. Drain spacings required for drainage of these soils may vary from 7.6m(25ft) to 11m(36ft) for clay soils and from 23m(75.4ft) to 48.8m(160ft) for silt loam soils. In some soils, filters are required on the drain tubing to prevent sediment from clogging the drains. Also, crop response to drainage and crop prices vary from year to year. With so many variables involved, there was a need to assemble pertinent information for use in making decisions about investing in subsurface drainage. Thus, the purpose of this paper was to compile data from several subsurface drainage experiments that have been conducted in Louisiana in recent years and to use these data to evaluate the economic feasibility of installing subsurface drainage in the lower Mississippi Valley using 1992 crop prices.

PROCEDURE

Data required for this study include drain spacing, crop yield increases due to subsurface drainage, value of the crop increases, drain installation costs, and amortization period.

Drainage System Descriptions and Crops Tested:
Subsurface drainage systems were installed at seven locations in Louisiana during

the 1970s and early 1980s. In Terrebonne Parish, subsurface drainage systems were installed in 1972 with a wheel-type trencher on Mhoon silty clay loam with drains spaced 6.1m(20ft), 12.2m(40ft) without filter, 12.2m(40ft) with synthetic filter, and 24.4m(80ft) apart (Camp and Carter 1983). Three crops of sugarcane were grown during 1974-1976. Crop yields were measured each year.

In 1976, subsurface drains were installed in St. James Parish on Commerce silt loam. The ARS drain tube plow (Fouss, et al., 1972) was used to install the drains 24.4m(80ft), 36.6m(120ft), and 48.8m(160ft) apart (Carter and Camp 1982). The drains were installed without filters. Yields from eleven sugarcane crops, one wheat crop, and one soybean crop were measured during 1977-1990.

Subsurface drains were installed in Iberia Parish in 1978 on Jeanerette silty clay loam (Carter et al. 1987). The ARS drain tube plow was used to install drains 13.7m(45ft), 27.4m(90ft), and 41.1m(135ft) apart. The drains were installed with a filter. Sugar yields from nine crops were measured during 1980-1990.

Subsurface drains were installed on Baldwin silty clay in St. Mary Parish in 1978. The ARS drain tube plow was used to install drains 13.7m(45ft) and 27.4m(90ft) apart. The drains were installed with a filter initially but these were replaced in 1981 with drains without filters. A chain type trencher was used to install the drains in 1981. Sugar yields from nine crops were measured during 1980-1990.

Subsurface drains were installed in East Baton Rouge Parish in 1973 and 1984 on Commerce silt loam soil on Louisiana State University's Ben Hur Research Farm. In 1973, a ladder type trencher was used to install subsurface drains spaced 10m(33ft) apart in one tract and 20m(66ft) apart in another tract. The drains were installed without filters. In 1984, a chain-type trencher was used to install drain tubes spaced 30.5m(100ft) apart in three 4ha(10A) fields. The drains were installed without filters. Corn silage yields from eight crops were measured from the 10m(33ft) and 20m(66ft) spacing experiment during 1980-1987 and from four crops from the 30.5m(100ft) spacing experiment during 1984-1987.

Subsurface drains were installed in Tensas Parish on Sharkey clay in 1973. A chain-type trencher was used to install drains 7.6m(25ft) and 15.2m(50ft) apart. The drains were installed without a filter. Soybean yields from five crops were measured during 1974-1978.

Subsurface drains were installed on Sharkey clay at the Louisiana Agricultural Experiment Station in Iberville Parish in 1977. The ARS drain tube plow was used to install drains 5.5m(18ft) and 11m(36ft) apart. The drains were installed without filters. Yields from four crops of sugarcane, four crops of soybeans, and three crops of wheat were measured during 1978-1986.

With the exception of the drainage system on Sharkey clay in Tensas Parish, sumps with float activated electric pumps were used as drain outlets. In Tensas Parish, the subsurface drains emptied by gravity into a drainage ditch. With the exception of the drainage systems installed in East Baton Rouge Parish in 1973, laser equipment was used to install the subsurface drains on grade. A target system was used to keep the ladder type trencher on grade during drain installation in 1973.

At each subsurface drainage site, areas located nearby but without subsurface drains were used as experimental checks. Yield increases due to subsurface drainage were determined by comparing crop yields measured from the drained areas with those from the nondrained check areas. Detailed results for each experiment are not included in this paper because the results either have been reported previously or will be reported soon.

Crop Value Estimates:
The price a farmer receives for most of his products, including wheat and soybeans, varies considerably. The price varies with actual and predicted supplies and demands. On the other hand, the price for some crops, such as sugar, may be fixed for a certain period by law (Farm Act). Commodity market prices listed in April and May, 1992 for future trading of wheat, soybeans, and sugar were used in this study. These prices were $0.14/kg($3.84/bu) for wheat, $0.22/kg ($6.00/bu) for soybeans, and $0.48/kg($0.22/lb) for sugar. The farmer receives only $0.29/kg ($0.132/lb) for sugar because 40% of the market price is paid to the mill for processing the sugarcane juice into raw sugar. Corn silage was not included in the list of commodity market prices, therefore a price estimate of $33/t($30/T) for corn silage was provided by the Dairy Science Department at Louisiana State University. The value of crop yield increases due to subsurface drainage were determined from the yield increases attributed to subsurface drainage and the April/May, 1992 crop prices.

Drain Installation Cost Estimates:
The cost of materials for installing subsurface drains was based upon prices quoted by a supplier in the spring of 1992. The materials required to install subsurface drainage in a field 177m(580ft) by 457m(1500ft) which is 8.1ha(20A) were determined. The per ha(A) cost used in this study was 1/8(1/20) of the 8.1ha(20A) estimate. Each drain line required 457m(1500ft) of 101mm(4in) diameter drain tubing, five couplers, one end cap, one 152mm by 101mm(6in by 4in) reducer and one 152mm(6in) tee. The cost for drain tubing without a filter was $0.72/m($0.22/ft), drain tubing with a filter was $1.15/m($0.35/ft), end caps and couplers were $0.70 each, and reducers and tees were $3.85 each. The cost of 152mm(6in) diameter tubing for the main was $1.87/m($0.57/ft) with 183m(600ft) purchased because the tubing is supplied in 30.5m(100ft) coils. The cost of a sump and pump, for those sites where a gravity outlet cannot be used, was estimated at $247/ha($100/A) based on the recent cost of installing a sump ($2000) and by assuming that one sump will serve 8.1ha(20A). A farmer probably could construct a sump out of scrap materials and install it for much less than $2000. On the other hand, if shopping efforts were not prudent, a sump might cost more than $2000 to purchase and install.

No subsurface drainage contractors routinely operate or conduct business in the lower Mississippi Valley. This makes it difficult to determine drain installation cost. For this study, we estimated the cost at $0.92/m($0.28/ft) for installing the subsurface drainage materials. This value may be low for a contractor just getting started in a new territory with intermittent work, but it should be reasonable where competition exists among subsurface drainage contractors. For comparison purposes, installation charges in the Mid-Western United States vary from less than $0.49/m($0.15/ft) to more than $1.64/m($0.50/ft).

Amortization Period and Payment Estimates:
The life of a subsurface drainage system exceeds 19 years. Drainage systems installed by Camp and Carter in the lower Mississippi Valley in 1973 are still functioning today. Thus, an amortization period of 15 to 20 years appear to be reasonable; however, if lending institutions are involved, a shorter amortization period may be required. For this study, we selected a payback period of 10 years.

Thus, to justify installing subsurface drainage, the value of the average crop yield increase attributed to subsurface drainage must be adequate to pay for the drainage system within 10 years. For sugarcane, the value of the average yield increase in eight crops during a 10-year period must be sufficient to pay for a drainage system because sugarcane produces three crops in a four-year period. The fourth year is devoted to destroying the sugarcane stubble, fallowing the land for several months and then replanting the cane for the next three crops. Consequently, only eight cane crops can be produced in a ten-year period.

The annual payments required to repay the total cost of a drainage system over a ten-year period financed at 10 percent interest was determined from a formula commonly used in determining mortgage principal and interest payments. The crop yield increases required to justify the cost (make the annual payments) for installing subsurface drainage were determined for sugar, wheat, soybeans, and corn silage. The 1992 market price for these crops was used to determine the yield increase required. Sugar yield increases required to justify drain installation costs were adjusted for the two years in ten when the land is fallow.

RESULTS

Drain Installation Costs:
Drain installation costs for the 15 different drain spacings used in this study are shown in Table 1. Drain tubing costs are provided for drain tubes with and without filters even though filters were used on drains installed at only two sites. The total cost included a sump since one was required for subsurface drain outlets at most of the experimental sites. For sites where a sump is not needed, drain installation cost is $247/ha($100/A) less than the total cost shown in Table 1. Not included in this table is the cost of electricity required to power the pumps for discharging the drain effluent into drainage ditches. Electricity cost is relatively small and varies from site to site. The highest annual electricity cost for pumping averaged about $37/ha($15/A).

Table 1. Subsurface drain installation costs.

Spacing m(ft)	Drain Tubing: Amount m/ha(ft/A)	Drain Tubing: Cost[a] $/ha(A) no filter	Drain Tubing: Cost[a] $/ha(A) filter	Drain Fittings Cost[b] $/ha(A)	Install Cost[c] $/ha(A)	Total Cost[d] $/ha(A) no filter	Total Cost[d] $/ha(A) filter
5.5(18)	1823(2420)	1330(532)	2093(847)	94(38)	1675(678)	3331(1348)	4109(1663)
6.1(20)	1640(2178)	1184(479)	1883(762)	84(34)	1507(610)	3022(1223)	3721(1506)
7.6(25)	312(1742)	946(383)	1507(610)	77(31)	1206(488)	2476(1002)	3037(1229)
10.0(33)	1000(1320)	720(290)	1150(462)	69(28)	914(370)	1946(788)	2370(960)
11.0(36)	911(1210)	657(266)	1048(424)	67(27)	838(339)	1809(732)	2199(890)
12.2(40)	820(1089)	593(240)	941(381)	64(26)	754(305)	1658(671)	2006(812)
13.7(45)	729(968)	526(213)	838(339)	62(25)	670(271)	1505(609)	1816(735)
15.2(50)	656(871)	474(192)	754(305)	59(24)	603(244)	1384(560)	1663(673)
20.1(66)	497(660)	358(145)	571(231)	54(22)	457(185)	1117(452)	1329(538)
24.4(80)	409(544)	297(120)	469(190)	52(21)	376(152)	971(393)	1141(463)
27.4(90)	364(484)	262(106)	418(169)	52(21)	336(136)	879(363)	1053(426)
30.5(100)	328(436)	237(96)	378(153)	52(21)	301(122)	838(339)	978(396)
36.6(120)	273(363)	198(80)	314(127)	49(20)	252(102)	746(302)	862(349)
41.1(135)	243(323)	175(71)	279(113)	47(19)	222(90)	692(280)	796(322)
48.8(160)	205(272)	148(60)	237(96)	47(19)	188(76)	630(255)	719(291)

[a] Based on a cost of $0.72/m(0.22/ft) for 101mm(4in) drains without filter and $1.15/m(0.35/ft) for drains with filters.
[b] Fittings include couplers, reducers, tees, end caps, and 183m(600ft) of 152mm(6in) main line.
[c] Based on installation cost of $0.92/m($0.28/ft).
[d] Includes $247/ha($100/A) for a sump.

Drain installation costs, including the cost of the sump, ranged from $630/ha ($255/A) for drains without filters spaced 48.8m(160ft) apart to $4109/ha($1663/A) for drains with filters spaced 5.5m(18ft) apart (Table 1). The cost of sumps for drain outlets and filters on the drains to prevent drain clogging contribute significantly to the total drain installation costs. Sump cost varied from 7 percent of the total drain installation cost for drains without filters spaced 5.5m(18ft) apart to 39 percent of the total for drains without filters spaced 48.8m(160ft) apart. Filter costs varies from 12 percent of the total cost for drains spaced 48.8m(160ft) apart to 19 percent of the total for drains spaced 5.5m(18ft) apart.

Annual Payments and Crop Yields Required to Justify Drain Installation: Annual payments (includes principal and interest) required to pay for installing subsurface drainage systems with and without filters on the drains are shown in Table 2. Annual payments ranged from $99/ha($40/A) for non-filtered drains spaced 48.8m(160ft) apart to $652/ha($264/A) for filter-wrapped drains spaced 5.5m(18ft) apart (Table 2).

Crop yield increases required to justify the cost of installing subsurface drainage ranged from 424 kg/ha(378 lbs/A) sugar and 700kg/ha(10.4 bu/A) wheat for non-filtered drains spaced 48.8m(160ft) apart to 2800 kg/ha(2500 lb/A) sugar and 4620 kg/ha(68.6 bu/A) wheat for filter-wrapped drains spaced 5.5m(18ft) apart (Table 2). The increases in soybean and corn silage yields required to justify the cost of installing subsurface drainage ranged from 448 kg/ha(6.7 bu/A) soybeans and 2.99 t/ha(1.33 T/A) corn silage for non-filtered drains spaced 48.8m(160ft) apart to 2956kg/ha(44 bu/A) soybeans and 19.7t/ha(8.8T/A) corn silage for filter-wrapped drains spaced 5.5m(18ft) apart (Table 2).

Table 2. Crop yield increases needed to pay for subsurface drainage system financed at 10 percent interest for ten years.

Drain spacing m(ft)	Required Payments $/ha(A)/yr	Annual yield increases needed to pay drain installation costs Sugar kg/ha(lbs/A	Wheat kg/ha(bu/A)	Soybeans kg/ha(bu/A)	Corn silage t/ha(T/A)
		For drains without filters			
5.5(18)	529(214)	2270(2026)	3745(55.7)	2396(35.7)	15.98(7.13)
6.1(20)	479(194)	2058(1837)	3395(50.2)	2173(32.3)	14.49(6.47)
7.6(25)	393(159)	1686(1506)	2782(41.1)	1718(26.5)	11.87(5.30)
10.0(33)	309(125)	1326(1184)	2191(32.6)	1398(20.8)	9.34(4.17)
11.0(36)	287(116)	1230(1098)	2030(30.2)	1299(19.3)	8.66(3.87)
12.2(40)	263(106)	1124(1004)	1855(27.6)	1187(17.7)	7.91(3.53)
13.7(45)	240(97)	1029(919)	1697(25.3)	1086(16.2)	7.24(3.23)
15.2(50)	220(89)	944(843)	1558(23.2)	997(14.8)	6.65(2.97)
20.1(66)	178(72)	764(682)	1260(18.8)	806(12.0)	5.38(2.40)
24.4(80)	153(62)	658(587)	1085(16.1)	694(10.3)	4.63(2.07)
27.4(90)	143(58)	615(549)	1015(15.1)	650(9.7)	4.33(1.93)
30.5(100)	133(54)	573(511)	945(14.1)	605(9.0)	4.03(1.80)
36.6(120)	119(48)	509(454)	840(12.5)	538(8.0)	3.58(1.60)
41.1(135)	109(44)	467(417)	770(11.5)	493(7.3)	3.29(1.47)
48.8(160)	99(40)	424(378)	700(10.4)	448(6.7)	2.99(1.33)
		For drains with filters			
5.5(18)	652(264)	2800(2500)	4620(68.8)	2956(44.0)	19.71(8.80)
6.1(20)	591(239)	2534(2264)	4182(62.2)	2677(39.8)	17.85(7.97)
7.6(25)	482(195)	2068(1847)	3412(50.8)	2184(32.5)	14.56(6.50)
10.0(33)	376(152)	1612(1439)	2660(39.6)	1702(25.3)	11.35(5.07)
11.0(36)	348(141)	1495(1335)	2468(36.7)	1579(23.5)	10.56(4.70)
12.2(40)	319(129)	1368(1222)	2257(33.6)	1445(21.5)	9.63(4.30)
13.7(45)	289(117)	1241(1108)	2047(30.5)	1310(19.5)	8.74(3.90)
15.2(50)	264(107)	1135(1013)	1872(27.9)	1198(17.8)	7.99(3.57)
20.1(66)	210(85)	902(805)	1487(22.1)	952(14.2)	6.35(2.83)
24.4(80)	180(73)	774(691)	1278(19.0)	818(12.2)	5.45(2.43)
27.4(90)	168(68)	721(644)	1190(17.7)	762(11.3)	5.08(2.27)
30.5(100)	156(63)	668(596)	1102(16.4)	706(10.5)	4.70(2.10)
36.6(120)	136(55)	583(520)	962(14.3)	616(9.2)	4.11(1.83)
41.1(135)	126(51)	541(482)	892(13.3)	571(8.5)	3.81(1.70)
48.8(160)	114(46)	488(436)	805(12.0)	515(7.7)	3.43(1.53)

Crop yield increases measured from subsurface drainage systems:
The measured yield increases of sugar, wheat, soybeans, and corn silage, due to subsurface drainage, are shown in Table 3. The annual values of the yield increases are also listed in Table 3 alongside the yield increases. The crops whose increased yields were valued at more than the required annual payments and therefore justified the cost of installing subsurface drainage were identified by

Table 3. Crop yield increases measured from subsurface drainage experiments, the value of the crop yield increases and whether yield increases justified drain installation costs.

Site[a]	Soil	Drain Spacing m(ft)	Filter	-- Crops -- Name	No.	Average increase kg/ha(lb/A)	Value of Increase $/ha($/A)	Required Payment $/ha($/A)	Drain Cost Justified
Ter.	sicl	6.1(20)	No	Sugar	3	7963(178)	47(19)	479(194)	No
Ter.	sicl	12.2(40)	No	Sugar	3	8267(449)	116(47)	263(106)	No
Ter.	sicl	12.2(40)	Yes	Sugar	3	7803(36)	12(5)	319(129)	No
Ter.	sicl	24.4(80)	No	Sugar	3	7993(230)	74(30)	153(62)	No
StJ.	sil	24.4(80)	No	Sugar	11	791(706)	185(75)	153(62)	Yes
StJ.	sil	36.6(120)	No	Sugar	11	421(376)	99(40)	119(48)	No
StJ.	sil	48.8(160)	No	Sugar	11	296(264)	69(28)	99(40)	No
StJ.	sil	24.4(80)	No	Wheat	1	1226(18.2)[c]	173(70)	153(62)	Yes
StJ.	sil	36.6(120)	No	Wheat	1	1569(23.4)[c]	222(90)	119(48)	Yes
StJ.	sil	48.8(160)	No	Wheat	1	1513(22.5)[c]	212(86)	99(40)	Yes
Iba.	sicl	13.7(45)	Yes	Sugar	9	1051(938)	244(99)	289(117)	No
Iba.	sicl	27.4(90)	Yes	Sugar	9	1039(928)	244(99)	168(68)	Yes
Iba.	sicl	41.1(135)	Yes	Sugar	9	798(713)	185(75)	126(51)	Yes
StM.	sic	13.7(45)	No	Sugar	8	409(365)	96(39)	240(97)	No
StM.	sic	27.4(90)	No	Sugar	8	000(000)	00	143(58)	No
EBR.	sil	10.0(33)	No	Corn	8	6.90(3.08)[b]	228(92)	376(152)	No
EBR.	sil	20.1(66)	No	Corn	8	9.07(3.67)[b]	326(110)	178(72)	Yes
EBR.	sil	30.5(100)	No	Corn	4	6.94(3.10)[b]	230(93)	133(54)	Yes
Ten.	c	7.6(25)	No	Beans	5	263(3.9)[c]	57(23)	393(159)	No
Ten.	c	15.2(50)	No	Beans	5	137(2.0)[c]	30(12)	220(89)	No
Ibr.	c	5.5(18)	No	Sugar	4	122(109)	30(12)	529(214)	No
Ibr.	c	11.0(36)	No	Sugar	4	644(575)	151(61)	287(116)	No
Ibr.	c	5.5(18)	No	Beans	4	253(3.8)[c]	57(23)	529(214)	No
Ibr.	c	11.0(36)	No	Beans	4	200(3.0)[c]	44(18)	287(116)	No
Ibr.	c	5.5(18)	No	Wheat	4	591(8.8)[c]	84(34)	529(214)	No
Ibr.	c	11.0(36)	No	Wheat	4	544(8.1)[c]	77(31)	287(116)	No

[a] Site abbreviations were for the following parishes: Ter.(Terrebonne), StJ.(St. James), Iba.(Iberia), StM.(St. Mary), EBR.(East Baton Rouge), Ten.(Tensas), and Ibr.(Iberville).
[b] ton/ha(T/A)
[c] kg/ha(bu/A)

'Yes' in the Drain Cost Justified column in Table 3. The crops listed in Table 2 whose increase in yield values were less than the annual payment required to pay for the drainage system were identified by 'No' in the Drain Cost Justified column in Table 3.

DISCUSSION

Subsurface drainage increased yields of sugarcane and corn silage on Commerce silt loam soil and sugarcane on Jeanerette silty clay loam soil sufficiently to justify the installation cost and the financing thereof for 10 years at 10 percent interest (Table 3).

The measured crop yield increases, attributed to subsurface drainage, justified installing drains 24.4m(80ft) apart on Commerce soil for sugarcane production and 20.1m(66ft) and 30.5m(100ft) apart on Commerce soil for corn silage production (Table 3). Measured sugar yield increases on the Jeanerette soil justified installing drains 27.4m(90ft) and 41.1m(135ft) apart (Table 3).

Crop yield increases were not sufficient to justify subsurface drainage of Baldwin silty clay and Sharkey clay soil, which is the predominant soil type in the lower Mississippi Valley (Table 3). At the Iberville site where wheat and soybeans were double cropped, the combined yield of two annual crops were still insufficient to justify the high cost for draining clay soil. The value of enhanced trafficability was not included in this study but it could be the deciding factor in whether to subsurface drain clay soil. Most farmers plan the entire farm operation around field activities on "heavy" (clay) soils. Getting into fields at the proper time may mean the difference between a good crop and a poor one. Getting into the field to harvest the crop between rainy periods is certainly important and the value of doing so should be included in justifying the cost of a drainage system. However, estimating the value of trafficability is difficult.

Two studies, one with sugarcane on Mhoon silt loam in Terrebonne parish and one with wheat on Commerce silt loam in St. James parish, resulted in data which were borderline for justifying subsurface drainage. Unusually dry weather conditions during two years of the three-year study in Terrebonne parish prevented the collection of representative data to justify subsurface drainage of Mhoon silty clay loam soil (Table 3). In 1974, rainfall was only 1060mm(41.73in), 600mm(23.6in) below normal and in 1976, rainfall was 1160mm(45.67in), 500mm(19.7in) below normal. Extremely low rainfall, like that in 1974 and 1976, is rare. In the past 42 years, annual rainfall at Houma, Louisiana was less than 1200mm(47in) only twice. In 1975, when sugarcane responded positively to subsurface drainage, rainfall was 1820mm(71.65in). The frequency of annual rainfall amounts in this range, 1500mm(59in) to 1800mm(71in), is common. During the past 42 years annual rainfall at Houma, Louisiana exceeded 1820mm(71.7in) eleven times and exceeded 1500mm(59in) 27 times. In 1975, sugar yields were increased significantly by subsurface drainage. Yields from the subsurface drained areas were 20 percent more than the check (Camp and Carter 1983). Mhoon soil is similar to Commerce except Mhoon has a very distinct 30cm(12in) thick layer of silt located approximately 1.2m(4ft) below the soil surface while layers of silt in the Commerce soil are not always connected and their depths vary. The distinct silt layer in the Mhoon soil enhances subsurface drainage to the extent that it drains more readily than the Commerce soil. If subsurface drainage is justified for Commerce soil, it should also be justified for Mhoon soil.

Wheat yield response to subsurface drainage of Commerce silt loam soil in St. James Parish in 1981 was excellent. Wheat yields for all three drain spacing treatments, 24.4m(80ft), 36.6m(120ft), and 48.8m(160ft), were 70 percent more than the check. Justification for installing subsurface drainage would be easy even for the close 24.4m(80ft) spacing drainage system (Tables 1 and 3) if a 70 percent increase in wheat yield could be expected every year. However, such yield increases are not expected routinely. During the wheat study, rainfall in the first half of February 1981 was 206mm (8.13in). Normal rainfall for February is 125mm(4.93in). No doubt, subsurface drainage contributed significantly to the wheat crop during this very wet period in February. Additional data are needed before a decision can be made about justifying subsurface drainage of Commerce soil for wheat production.

The increase in yields required to justify the cost of installing subsurface drainage, when drain spacing is closer than 10m(33ft) feet, is almost out of reach with the present crop varieties and cropping practices used for sugarcane, wheat, soybeans, and corn for silage. Justification is more likely to be achieved with sugarcane and corn silage than with wheat and soybeans. For example, to justify installing drains 7.6m(25ft) apart requires an increase in sugar yield of 1686kg/ha(1506lb/A) which is 27 percent more than the Louisiana state average yield of 6325kg/ha(5647lb/A) and a yield increase of 11.87t/ha(5.30T/A) corn silage which is 37 percent more than the state average yield of 35.33t/ha(14.30T/A). For soybeans, an increase of 1718kg/ha(26.5bu/A) is required to justify 7.6m(25ft) spaced drains which is 106 percent more than the 1680kg/ha (25bu/A) state average in Louisiana and for wheat an increase of 2782kg/ha(41.1bu/A) is required which is 121 percent more than the 2285 kg/ha (34bu/A) state average yield. Even higher yield increases would be required to justify closer drain spacings such as 6.1m(20ft) and 5.5m(18ft).

Three costs which contribute significantly to the overall cost of installing subsurface drainage, but are not always necessary in subsurface drainage systems, are sumps for subsurface drain outlets, filters to prevent drain clogging, and interest on funds to pay for the subsurface drainage system. Interest on funds to install subsurface drainage probably does not hinder many farmers from installing subsurface drainage although in the cases presented in this paper, a subsurface drainage system financed for 10 years at 10 percent interest cost 58 percent more than drainage systems that were not financed. This high cost should encourage farmers to pay for the drainage system outright rather than borrow funds.

Filters on drain tubes boost subsurface drainage cost considerably. Drain tubes

101mm(4-in) in diameter with synthetic filter cost 59 percent more than drains without filters. Thus, they should be used only where a definite need for filters exist.

The need for sumps may be the major reason why farmers are not installing subsurface drainage in the lower Mississippi Valley. The deciding factor may not be the initial cost of the sump, but the need for electricity to power the sump pumps. Farmers, in general, do not like electric power lines in their fields because they interfere with aerial applications of fertilizers and pesticides. Furthermore, the cost of constructing power lines to the subsurface drainage site may not be justified. Investigation of solar and/or wind power to solve this problem is needed.

SUMMARY

The cost of installing subsurface drainage was justified for Commerce silt loam with 24.4m(80ft) drain spacing for sugarcane, for Commerce silt loam with 20m(66ft) and 30.5m(100ft) drain spacing for corn silage, and for Jeanerette silty clay loam with 27.4m(90ft) and 41.1m(135ft) drain spacing for sugarcane. Crop yield increases resulting from subsurface drainage of Baldwin silty clay and Sharkey clay were not sufficient to justify the cost of installing subsurface drainage systems. More data are needed to determine whether installing subsurface drainage can be justified on Mhoon silty clay loam soil for sugarcane and Commerce silt loam soil for wheat.

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